U.S. Army Center for Health Promotion and Preventive Medicine

Injuries Among Army Light-Wheel Vehicle Mechanics
USACHPPM Report No. 12-MA-7193A-06

US Army Center for Health Promotion
and Preventive Medicine
Aberdeen Proving Ground, MD

and

US Army Research Institute
of Environmental Medicine
Natick, MA

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Readiness Thru Health

USACHPPM

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) lineage can be traced back over 50 years to the Army Industrial Hygiene Laboratory. That organization was established at the beginning of World War II and was under the direct jurisdiction of The Army Surgeon General. It was originally located at the Johns Hopkins School of Hygiene and Public Health, with a staff of three and an annual budget not to exceed $3000. Its mission was to conduct occupational health surveys of Army operated industrial plants, arsenals, and depots. These surveys were aimed at identifying and eliminating occupational health hazards within the Department of Defense's (DOD) industrial production base and proved to be beneficial to the Nation's war effort.

Until 1995, it was nationally and internationally known as the U.S. Army Environmental Hygiene Agency or AEHA. Its mission is expanding to support the worldwide preventive medicine programs of the Army, DOD and other Federal Agencies through consultations/ supportive services; investigations and training.

Today, AEHA is redesignated the U.S. Army Center for Health Promotion and Preventive Medicine. Its mission for the future is to provide worldwide technical support for implementing preventive medicine, public health and health promotion/wellness services into all aspects of America's Army and the Army Community anticipating and rapidly responding to operational needs and adaptable to a changing work environment.

The professional disciplines represented at the Center include chemists, physicists, engineers, physicians, optometrists, audiologists, nurses, industrial hygienists, toxicologists, entomologists, and many other as well as sub-specialties within these professions.

The organization's quest has always been one of excellence and continuous quality improvement; and today its vision, to be the nationally recognized Center for Health Promotion and Preventive Medicine, is clearer than ever. To achieve that end, it holds ever fast to its values which are steeped in its rich heritage:

- *Integrity is the foundation*
- *Excellence is the standard*
- *Customer satisfaction is the focus*
- *Its people are the most valued resource*
- *Continuous quality improvement is its pathway*

The organization, which stands on the threshold of even greater challenges and responsibilities, has General Officer leadership. As it moves into the next century, new programs are being added related to health promotion/wellness, soldier fitness and disease surveillance. As always, its mission focus is centered upon the Army Imperatives so that we are trained and ready to enhance the Army's readiness for war and operations other than war.

It is an organization fiercely proud of its history, yet equally excited about the future. It is destined to continue its development as a world-class organization with expanded services to the Army, DOD, other Federal Agencies, the Nation and the World Community.

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Joseph J Knapik, Sarah B Jones, Salima Darakjy, Keith G Hauret, Steven Bullock, Stephanie Morrison, Sara Canada, Edward Hoedebecke, Michelle Canham-Chervak, Marilyn A Sharp, Lolita Burrell, Bruce H Jones

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14. ABSTRACT
The medical records of 518 male and 43 female mechanics at Fort Bragg, North Carolina were screened for injuries occurring in a 1-year period. An injury was defined as an event in the medical record indicating the Soldier sought medical care for an overuse or traumatic condition. Weight, height, age, and ethnicity were also extracted from the medical records; body mass index (BMI) was calculated as weight/height*height. The person-time injury rates for men and women were 124 and 156 injuries/100 person-years, respectively. Limited duty days for men and women were 2076 and 1966 days/100 person-years, respectively. For the men, 34% of the injuries involved the upper body, 19% the lower back and 46% the lower body. For women, 24% of the injuries involved the upper body, 10% the lower back, and 62% the lower body. Activities associated with injury included (in order of incidence) physical training, mechanical work, sports, airborne-related activities, road marching, garrison/home activities, and chronic conditions. Among the men, elevated injury risk was associated with greater weight and greater BMI.

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DEPARTMENT OF THE ARMY
US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND MD 21010-5403

EXECUTIVE SUMMARY
INJURIES AMONG ARMY LIGHT-WHEEL VEHICLE MECHANICS
USACHPPM REPORT NO. 12-MA-7193A-06

1. INTRODUCTION. Previous investigations of outpatient injury rates in specific military occupational specialties (MOS) have involved infantrymen, combat engineers, field artillerymen, military police, and armor crewmen. The purpose of this investigation was to expand MOS-specific injury information by examining injury rates, activities associated with injury, anatomical locations, and potential injury risk factors in Army light-wheel vehicle mechanics.

2. METHODS.

a. A list of all Soldiers with an MOS code of 63B (light-wheel vehicle mechanics) who were located at Fort Bragg, North Carolina, was obtained from the Standard Installation Division Personnel System (SIDPERS). The medical records of these Soldiers were examined for the period 1 March 2003 to 29 February 2004 (1 year). For each injury-related medical visit, information extracted from the medical records included the date of the visit, type of visit (first or follow-up), activity associated with the injury, diagnosis, anatomical location, disposition (final outcome of the visit), and days of limited duty (if any). Also extracted were date of birth, height, weight, and ethnicity. In cases where the medical care provider did not supply an activity associated with the injury, an attempt was made to contact the Soldier to obtain this information.

b. Injury cases were Soldiers who sustained physical damage to the body and sought medical care as recorded in the medical record. Injuries were grouped by “type” and “level” for analysis. “Types” included any injury, overuse injury, traumatic injury, and lower extremity overuse injury. An overuse injury was presumably due to or related to long-term energy exchanges resulting in cumulative microtrauma (e.g., stress fractures, tendinitis, bursitis). A traumatic injury was presumably due to sudden energy exchanges resulting in abrupt overload with tissue trauma (e.g., fractures, dislocations, contusions). A lower extremity overuse injury was an overuse injury that also involved the lower extremity or lower back. “Any injury” included overuse and traumatic cases. The first injury “level” included all visits to a health care provider whether or not limited duty was prescribed. The second “level” included only those injuries that resulted in one or more days of limited duty. Combining injury types and levels resulted in 8 injury measures: any injury, overuse injury, traumatic injury, lower extremity overuse injury, time-loss injury, time-loss overuse injury, time-loss traumatic injury, and time-loss lower extremity overuse injury.

c. Medical records did not contain deployment medical visits so deployment times were obtained from the Defense Manpower Data Center. Injury rate was calculated as injury cases divided by the total number of person-years minus deployment time within the project timeframe.

3. RESULTS.

a. There were 518 men and 43 women who had complete medical records and were included in the analysis. Men had a total of 464 injuries and women had a total of 50 injuries. Injury rates (any injury) for the men were 124 cases/100 person-years and for the women, 156 cases/100 person-years. Women had higher injury rates than men for overuse injury, lower extremity overuse injury, time-loss overuse injury, and time-loss lower extremity overuse injury. Men had higher injury rates than women for traumatic injury and time-loss traumatic injury. Men experienced 2076 limited duty days/100 person-years while women had 1966 limited duty days/100 person-years.

b. For the men, 34% of the injuries occurred in the upper body, 19% in the lower back and 46% in the lower body. The single sites with the largest proportion of male injuries were the low back (19%), knee (16%), ankle (12%), foot (7%), and shoulder (7%). For women, 24% of the injuries occurred in the upper body, 10% in the lower back and 62% in the lower body. The single sites with the largest proportion of female injuries (in order of incidence) were the knee (26%), low back (10%), foot (10%), ankle (8%), neck (6%), and shoulder (6%). Overuse injuries accounted for 48% of the male injuries and 68% of the female injuries; traumatic injuries accounted for 49% of the male injuries and 32% of the female injuries (3% of male injuries could not be classified as either overuse or traumatic).

c. For both men and women, activities associated with injury were obtained in 90% of the injury cases. The major activities associated with injuries (with proportion accounted for in parentheses) were physical training (men 22%, women 36%), mechanical work (men 12%, women 18%), sports (men 11%, women 0%), airborne operations (men 9%, women 9%), road marching (men 7%, women 9%), garrison/home activities (men 7%, women 9%), and chronic conditions (men 6%, women 7%). Of the physical training injuries, running accounted for the largest proportion; of the male sports injuries, basketball accounted for the largest proportion. Of the male mechanical work injuries, activities related to vehicle tires, wrenches slipping, objects dropped on the body, and vehicle starters accounted for the most; of the female mechanical injuries, objects dropped on the body accounted for most. Almost all airborne injuries were associated with inappropriate parachute landing falls.

d. Cox regression analyses were used to examine the association of time to first injury with the following potential risk factors: age, height, weight, body mass index (BMI, weight/height^2) and ethnicity. Injury risk factors were examined only in the men because of the small number of women. Greater BMI was associated with higher injury risk regardless of the injury measure. In univariate analysis, older age and “Other” ethnicity were associated with overuse injury but these relationships were considerably weakened when considered in a multivariate model with BMI. BMI systematically varied with age and ethnicity.

4. DISCUSSION.

a. Some gender differences emerged among the mechanics but the small number of women (n=43) suggests a cautious approach in interpreting these differences. Men tended to have a

higher traumatic injury rate while women had a higher overuse injury rate. A previous study examining primarily traumatic injuries at Fort Lewis, Washington found that men were 1.20 times more likely to be injured than women. This generally agrees with the results here in which male mechanics experienced a traumatic injury rate that was 1.26 times higher than that of the female mechanics. This could be related to higher male risk-taking behavior.

b. Infantrymen, military police, and mechanics are MOSs for which activities associated with injuries have been examined. In consonance with the mechanic's data, physical training has been shown to be the activity that is associated with the largest proportion of injuries in other MOSs. In the present project, most of the physical training injuries were associated with running. Running is a popular exercise in the military and is performed on a regular basis. The 2-mile run is an Army Physical Fitness Test (APFT) event for which all Soldiers must meet certain age and gender adjusted standards on a biannual basis. However, both civilian and military investigations have shown that injury incidence increases as the volume of running increases. Targeted reductions in running mileage have been shown to reduce injury risk without having significant effects on running performance.

c. Mechanical work was the second most common activity associated with injury. Based on an ergonomic task analysis, much of the occupational work of mechanics involves the upper body and low back in the use of hand tools (torque applied to tools like wrenches and screwdrivers) and for removing and replacing vehicle parts like radiators, fuel pumps, alternators, batteries, starters, brakes, tires, axles, wheels and hubs. Interventions to reduce injuries during these tasks should be explored.

d. Higher BMI was associated with higher injury risk among the male mechanics. Higher BMI was also an injury risk factor in studies on military police, armor crewmen, infantrymen, and in combined combat engineers and artillerymen. It would appear that Soldiers who carry more body weight for their height are at higher injury risk. The higher weight may result in greater forces on body tissues during physical activity resulting in a greater likelihood of injury.

5. CONCLUSIONS. This project identified injury rates, types of injuries, anatomical locations of injuries, activities associated with injuries, and some injury risk factors among Army light-wheel vehicle mechanics. Women had a higher overall injury rate than men (156 versus 124 injuries/100 person-years). Most of the higher overall injury rate of the women was due to overuse injuries; men had a higher traumatic injury rate. The average mechanic had about 20 days of limited duty each year. The largest proportion of injuries was experienced in the lower back, knee, and ankle areas. Physical training and mechanical work were the two activities associated with the highest proportion of the injuries. Among men, greater BMI was associated with a higher likelihood of injury.

INJURIES AMONG ARMY LIGHT-WHEEL VEHICLE MECHANICS
USACHPPM REPORT NO. 12-MA-7193A-06

1. REFERENCES. Appendix A contains the references used in this report.

2. INTRODUCTION.

a. Individuals entering the United States Army can select from over 250 military occupational specialties (MOSs) that reflect the wide range of mission requirements and the technical expertise needed in the Army (1). Pre-enlistment screening, the requirement for regular physical training, enforced weight-for-height standards, and free health care all contribute to the fact that Soldiers are generally healthier than their age-adjusted civilian counterparts (2, 3). Despite this, the requirements for regular vigorous exercise and realistic operational training appear to put Soldiers at high risk of injury. Injuries are a major problem in the military (4, 5) resulting in 5 to 22 times more days of limited duty than those arising from illnesses (6, 7).

b. There have been a considerable number of studies examining outpatient injury rates in Basic Combat Training (BCT) (8-16) and a few studies investigating injuries in Advanced Individual Training (AIT) (17, 18). Studies of injury rates in specific MOSs have been limited to infantrymen (19-21), combat engineers (22, 23), field artillerymen (22), military police (24), and armor crewmen (25). The emphasis on the study of combat MOSs (infantry, combat engineers, and armor crewmen) is well founded since these MOSs appear to have some of the highest rates of injury hospitalizations in the Army (26). However, it is necessary to expand the investigation of injury rates to other MOSs and to better describe the activities that are associated with these injuries as a first step in the injury prevention process. The emphasis on examining combat MOSs has not allowed a comparison of men and women serving in the same MOSs since combat MOSs are closed to women.

c. The purpose of this investigation was to expand the MOS-specific injury information by examining outpatient injury rates in Army light-wheel vehicle mechanics (MOS number 63B (1). In addition to describing injury rates, activities associated with injury, anatomical location of the injuries, and potential injury risk factors were also examined. Male and female injury rates were compared and contrasted.

3. BACKGROUND. Studies focusing on Soldiers in specific MOSs have examined injury hospitalizations (26), injury disability (27, 28), and outpatient injury medical visits (19-25, 29). Studies on outpatient injuries frequently include information on specific injury risk factors for injuries. As might be expected, injury rates and injury risk factors differ in the various MOSs, which may be associated with the nature of the occupational tasks and the amount of physical training performed.

a. *Injury Hospitalizations in Various Military Occupational Specialties*. Analysis of injury hospitalizations in the 25 most populated enlisted MOSs (accounting for about 50% of the Army enlisted population) was performed using the Total Army Injury and Health Outcomes Database (TAIHOD) for 1990-1994 (26). Injuries were defined by International Classification of Diseases, Version 9 (ICD-9) codes 800-904, 910-957, and 960-995. Injury-related musculoskeletal conditions were defined by ICD-9 codes 710-739. A summary of the results is shown in Table 1. Nine MOSs were classified as "combat" and only open to men while the other 16 MOSs were open to both men and women. Among men, the MOSs with the highest injury hospitalization rates and musculoskeletal injury hospitalization rates are primarily among the combat (male only) specialties and medical specialists (MOS number 91A). Among women, the highest injury hospitalization rates were among the medical specialists (MOS number 91A), while wheel mechanics ranked first for musculoskeletal injury hospitalizations.

b. *Injury Disabilities in Various Military Occupational Specialties*.

(1) Another study (27) examined musculoskeletal disability cases in the military during 1990-1994 using the US Army Physical Disability Database. Among the men, infantry Soldiers had the highest disability incidence at about 18/1000 Soldiers. Male light-wheel vehicle mechanics had the14th highest disability incidence among all Army MOS with a rate of about 12 cases/1000 Soldiers. Among women, multichannel and single channel radio operators had the highest disability incidence (23 and 21/1000, respectively), with light-wheel vehicle mechanics ranking third among all Army MOS with a rate of about 20 cases/1000.

(2) In a separate study, occupational back disability cases in the Army were examined in the 1990-1994 period using the Physical Disability Database (28). Among men, infantry Soldiers had the highest disability incidence at 4.6 cases/1000 and light-wheel vehicle mechanics had the 9th highest disability rates at about 3.5 cases/1000. Among women, interrogators had the highest disability rate at 7.8 cases/1000 while wheel vehicle mechanics ranked third at 5.2 cases/1000.

c. *Outpatient Injury Rates and Risk Factors in Specific MOS*.

(1) While injury hospitalization and disability data are important for describing the impact of the most serious injuries, they do not supply the entire picture. Outpatient medical visits account for a much larger proportion of medical encounters (6) and provide a more complete accounting of the size of the injury problem. Table 2 shows data extracted from studies examining outpatient injury rates in different MOSs.

Table 1. Number of Soldiers and Injury/Musculoskeletal Injury Hospitalization Rates in the 25 Most Populated MOSs (26)

Military Occupational Specialty (Specialty Code)	Gender	Population (n)	Injury Hospitalization Rate (injury hospitalizations/ 1000 person-years)	Injury-Related Musculoskeletal Conditions Hospitalization Rate (cases/1000 person years)
Infantryman (11B)	Men	194,384	26.0	24.8
Indirect Fire (11C)	Men	35,822	22.1	19.4
Heavy Anti-armor Weapons (11H)	Men	27,850	22.1	23.4
Fighting Vehicle Crewman (11M)	Men	71,738	22.4	17.3
Combat Engineer (12B)	Men	55,719	23.0	20.6
Cannon Crewmember (13B)	Men	96,059	21.4	19.1
Fire Support Specialist (13F)	Men	27,249	21.2	21.3
Cavalry Scout (19D)	Men	43,602	22.7	18.4
Armor Crewman) (19K)	Men	73,069	22.1	18.7
Radio Operator-Maintainer (31C)	Men Women	23,459 2,902	17.8 13.8	18.7 24.8
Combat Signaler (31K)	Men Women	21,568 1,233	16.8 12.2	15.5 30.8
Power Generation Equipment Repairer (52D)	Men Women	27,944 1,364	16.8 13.9	19.5 29.3
Chemical Operations Specialist (54B)	Men Women	34,995 3,415	17.6 14.6	22.8 30.8
Wheel Vehicle Mechanic (63B)	Men Women	74,574 6,035	15.5 13.4	22.1 31.0
Track Vehicle Repairer (63H)	Men Women	21,996 1,266	13.7 6.4	23.6 21.3
Administrative Specialist (75B)	Men Women	43,062 35,265	11.7 7.9	20.5 19.6
Personnel Administrative Specialist (75B)	Men Women	20,380 6,776	12.5 8.6	19.5 19.0
Equipment Records & Parts Specialist (76C)	Men Women	18,955 5,740	14.7 12.0	18.2 20.6
Unit Supply Specialist (76Y)	Men Women	49,196 13,518	14.4 9.2	19.4 20.7
Petroleum Supply Specialist (77F)	Men Women	30,629 7,309	17.3 17.9	19.9 22.2
Motor Transport Operator (88M)	Men Women	60,836 10,022	19.0 14.3	21.7 24.1
Medical Specialist (91A)	Men Women	20,549 5,631	23.8 20.6	20.7 30.0
Medical Specialist (91B)	Men Women	59,609 13,472	16.8 12.4	24.8 28.1
Food Service Specialist (94B)	Men Women	57,189 15,284	15.8 14.2	19.2 19.2
Military Police (95B)	Men Women	88,138 10,293	15.3 15.3	20.4 24.0

Table 2. Outpatient Injury Rates, Clinic Visit Rates, and Limited Duty Rates of US Army Soldiers in Various MOSs

Study (Reference Number)	Year Data Collected	Type of Unit	Rate (events/100 person-months)		Limited Duty Rate (days/100 person-years)[c]
			Injuries[cd]	Clinic Visits for Injuries[c]	
Tomlinson et al. (29)[a]	1984-1985	Infantry	12.2	ND	ND
		Infantry	18.6	ND	ND
		Special Forces	12.1	ND	ND
		Rangers	10.1	ND	ND
		Aviation/Artillery	4.5		
Knapik et al. (19)[b]	1989	Infantry	11.8	18.3	1184
Reynolds et al. (20)	1989-1990	Infantry	ND	15.1	609
Reynolds et al. (22)	1996	Combat Engineers	ND	16.8	594
		Artillery	ND	12.3	573
Smith and Cashman (21)	1997-1998	Infantry	8.4	ND	1573
Hauret et al. (24)	2002	Military Police	9.2	19.2	3250
Darakjy et al. (25)	2002	Armor	5.7	11.0	1580

[a]Annualized rates based on 8 weeks of data collection
[b]Annualized rates based on 6 months of data collection
[c]ND=No data
[d]An injury is the first visit for a particular type of physical damage to the body. A Soldier could have more than one injury.

(2) Tomlinson et al. (29) monitored Soldiers reporting to 4 Troop Medical Clinics (TMCs) at Fort Lewis, Washington over an 8-week period. They also looked at injury hospitalizations but since the large majority of visits were outpatient (86%), the study is considered in this section. Injuries were recorded as Soldiers entered the clinic and a questionnaire was used to obtain additional information. Injuries examined were primarily traumatic and environmental (heat/cold); overuse injuries were apparently not considered. Among 15,295 Soldiers in the 9th Infantry and First Corps, there were 478 new injuries for an annualized rate of 81 injuries/100 Person-years (6.8 injuries/100 person-months). Injury rates differed in various TMCs supporting different types of military units. Fifty-five percent of injuries were associated with sports and exercise. Forty percent of the injured Soldiers were returned to duty and 52% were given limited duty, 14% were hospitalized, and 5% were assigned to quarters. Differences were noted among 2 infantry battalions, a ranger battalion, and a Special Forces group as shown in Table 2. Of the 335 injuries that occurred in garrison, locations included the gymnasium/athletic field (38%), quarters/neighborhood (16%), motor pool/hanger (12%) and field and forest (6%). All Soldiers (regardless of MOS) were combined and a case-control study was conducted (controls were Soldiers reporting to the clinic who were uninjured). It was found that the odds of injury were higher among Soldiers who were men (odds ratio (OR)=2.5(95% confidence interval (95%CI)=1.4-4.7)), younger (OR(17-21 yrs/22-46 yrs)=1.4(95%CI=1.1-1.9)), of lower rank (OR(E1-E3/E4-E9)=1.4(95%CI=1.1-1.8)), in combat units (OR(combat/combat service or service support)=1.5 (95%CI=1.1-2.0)), single (OR(single/married)=1.4 (95%CI=1.1-1.8)), lived in on-post housing (OR(on-post/off-post)=1.5 (95%CI=1.2-2.0)), and exercised longer during the week (OR(0-9 hrs/≥10hrs)=1.8(95%CI=1.4-2.4)). Injury was not associated with race, alcohol consumption, or history of injury in the last 6 months.

(3) Knapik et al. (19) examined injuries over a 6-month period among 298 male Soldiers assigned to a light infantry battalion at Fort Richardson, Alaska. Injuries were abstracted from the Soldier's medical records. Additional data obtained from unit records included age and Army Physical Fitness Test (APFT) scores. The APFT consisted of a maximal effort push up event (2 minutes), a maximal effort sit-up event (2 minutes), and a 2-mile run for time. Injuries were defined more broadly than by Tomlinson et al (29) and included traumatic, overuse, and

environmental injuries. Despite the difference in the injury definition, injury rates were comparable to those reported by Tomlinson et al. (29). Over the 6-month period, 51% of the Soldiers experienced one or more injuries with a total of 212 injuries and 327 clinic visits. The annualized injury rate was 142 injuries/100 person-years (11.8 injuries/100 person-months). The annualized clinic visit rate was 219 visits/100 person-years (18.3 visits/100 person-months). Soldiers were given a total of 1764 days of limited duty for an annualized rate of 11.8 days/person-year. Injury risk was elevated among younger Soldiers (relative risk (RR) (<20yrs/>24yrs)=1.1), those with slower 2-mile run times (RR(slowest 25%/fastest 25%)=1.6) and those performing fewer sit-ups (RR=(lowest 25%/highest 25%)=1.5).

(4) Reynolds et al. (20) examined injuries over a one-year period among 181 male light infantry Soldiers at Fort Drum, New York. Soldiers completed a questionnaire that inquired into their lifestyle and past injuries and direct measurements were taken of their height, weight, body fat (circumference technique), flexibility (sit-and-reach test), and hand grip strength. APFT scores were obtained from the unit. Injuries were obtained by screening medical records and injuries were defined similar to Knapik et al. (19). During the 1-year period, 101 Soldiers (56%) experienced one or more injuries for which they made 328 clinic visits for an annualized clinic visit rate of 182 visits/100 person-years (15.2 visits/100 person-months). Soldiers were given a total of 1103 days of limited duty for an annualized rate of 6.1 days/person-year. Lower extremity and low back injuries were related to body fat (relative risk (RR)(fattest quintile/leanest quintile)=1.7), slower 2-mile run time (RR (slowest quintile/fastest quintile)=1.6), fewer sit-ups (RR(fewest quintile/most quintile)=1.5), and cigarette smoking (RR(>10 cigarettes per day/nonsmokers)=1.7). BMI showed a bimodal relationship with the highest and lowest quintile demonstrating elevated risk compared to the middle quintile (RR=2.2 and 1.7, respectively). In multivariate analysis, smoking history and 2-mile run times were independent risk factors for injury.

(5) Reynolds et al. (22) examined injuries over a 1 year period among 125 male combat engineers and 188 male combat artillerymen at Fort Drum, New York. Soldiers completed a questionnaire on their age, ethnicity and cigarette smoking history. Soldier height, weight and APFT scores were obtained from the units involved in the study. Injuries were obtained from medical records and injury definitions were consistent with previous studies (19, 20). During the 1-year period, 108 engineers (86%) experienced one or more injuries and made 252 clinic visits. Of the combat artillerymen, 124 (66%) experienced one or more injuries and they made 277 clinic visits. The annualized clinic visit rate for the combat engineers was 201 visits/100 person-years (16.8 visits/100 person-months) and that for the combat artillerymen was 147 visits/100 person-years (12.3 visits/100 person-months). Days of limited duty were 743 for the combat engineers (5.9 days/So-year) and 1078 for the artillerymen (5.7 days/person-year). The engineer and artillerymen data was combined to examine risk factors for specific types of injuries. Risk factors for lower extremity pain included shorter height (OR(<170 cm/≥170 cm)=2.9 (95%CI=1.2-6.7)), and ethnicity (OR(Caucasian /Non-Caucasian)=1.9 (95%CI=1.2-3.0)). For low back pain, greater body weight was a risk factor (OR(<90 kg/≥90 kg)=2.5 (95%CI=1.2-5.5)). For strains and sprains, risk factors included shorter stature (OR(<170 cm/≥170 cm)=2.3 (95%CI=1.2-4.3)) and higher BMI (OR (≥25 kg/m^2/<25 kg/m^2)=2.1 (95%CI=1.2-3.4)).

(6) Reynolds et al. (23) reported a separate study of injuries among 147 combat engineers. Injuries over a one-year period were obtained by screening medical records and APFT scores were acquired. Sixty-eight percent of the Soldiers had one or more injuries. Soldiers with slower run times tended to have more injuries (RR (slowest 25%/fastest 25%)=1.5). Neither push-ups (p=0.92) nor sit-ups (p=0.74) were associated with injury.

(7) Smith and Cashman (21) examined injuries over a 13-month period among 339 infantry Soldiers of the 25th Infantry Division (Light) at Schofield Barracks, Hawaii. Injuries were obtained by screening medical records. No injury definition was provided. During the period, 213 Soldiers (63%) experienced one or more injuries and there were a total of 372 injuries. The annualized injury visit rate was 101 injuries/100 person-years (8.4 injuries/100 person-months). Days of limited duty totaled 5775 during the 13-month period for an annualized rate of 15.7 days/person-year. Activities associated with injury were obtained in 91% of the new injury cases (339/372) and the major activities were physical training (50%), foot marching (16%), job/field (14%), off-duty sports (8%), and off-duty other activities (14%). It was reported that Soldiers in lower enlisted ranks (E1-E5) were more likely to be injured than higher ranking Soldiers (E6-O6) but the data was not presented. Cigarette smokers were not more likely to get injured than non smokers but these data were also not presented.

(8) Hauret et al. (24) examined injuries over a 1-year period among 268 male military police at Fort Riley, Kansas. Injuries were obtained from medical records and injury definitions were consistent with past studies (19, 20, 22). Age, race, height, and weight were obtained from the medical records and APFT scores were obtained from the military unit. During the 1-year period, 140 Soldiers (52%) experienced one or more injuries, there were 213 new injuries, and there were 462 clinic visits. When only time assigned at Fort Riley was considered, the annualized new injury rate was 110 injuries/100 person-years (9.2 injuries/100 person-months). Soldiers were given a total of 6,529 days of limited duty (32.5 days/person-year). Fifty-two percent of injuries with known causes were related to physical training or sports while 34% were related to military training activities. Risk factors related to injury included age and higher BMI in both univariate analyses (age (continuous variable), RR=1.04 (95%CI=1.01-1.06); BMI (RR(highest quartile/lowest quartile)=2.5(95%CI=1.4-4.5)) and multivariate analysis (age (as a continuous variable), RR=1.03 (95%CI=1.00-1.06), BMI, RR(highest quartile/lowest quartile)=2.2(95%CI=1.8-4.0)).

(9) Darakjy et al. (25) examined injuries over a 1-year period among 426 armor Soldiers at Fort Riley, Kansas. Injuries were obtained from medical records and injury definitions were consistent with past studies (19, 20, 22). Age, height, weight, race, and APFT scores were obtained from the military unit. During the 1-year period, 139 Soldiers (33%) experienced one or more injuries; there were 205 new injuries, 397 clinic visits, and 4747 days of limited duty. When only the time that Soldiers were assigned to Fort Riley was considered, the annualized new injury rate was 46 injuries/100 person-years and 15.8 days limited duty/person-year. In multivariate analysis, high BMI (RR(highest quartile/lowest quartile)=2.3 (95%CI=1.1-4.9)) and lower rank (RR(lower enlisted/officers)=2.3 (95%CI=1.1-4.9)) were independent injury risk factors.

d. *Summary of Studies on Various Military Occupational Specialties.*

(1) Injury rates and injury risk factors vary by MOS. Infantrymen are the most studied MOS, but it is difficult to compare injury rates among infantrymen across studies because of differences in the injury definitions or lack of any definition at all. In the Tomlinson et al. study (29), two very different injury rates were reported for two different infantry units suggesting that rates can vary among units even within the same MOS using the same injury definition. However, Tomlinson et al. collected only 2 weeks of data then calculated annualized rates from these data. This short period of time may have introduced some data instability if there were major differences in the type or intensity of training in this period or seasonal variations (30). In the two studies of infantrymen that used a similar definition of injury (19, 20) the clinic visit rate was similar (injury rate was not reported in one study). The few studies on other MOSs suggest that compared to infantry Soldiers, the injury rate for armor crewmen (25) and for aviation/artillery units (29) are lower; however, the injury rate for military police (24) may be higher than some infantry units (21). Also the clinic visit rate for military police is the highest among all occupational groups for which this measure has been reported.

(2) The person-time limited duty days have also varied widely in different studies. This may be attributed to how well medical care providers have documented the days of limited duty in the medical records. Future studies examining limited duty days from medical records should report cases for which a profile (duty limitation) was prescribed but no limited duty days recorded in the medical record.

(3) Risk factors that have been studied in several MOSs include BMI, physical fitness (aerobic endurance measured by 2-mile run times and muscular endurance measured by push-ups and sit-ups) and age. The strength and direction of the association of these variables with injury appear to vary by MOS.

(4) High BMI was an injury risk factor among military police and armor crewmen (24, 25), but the relationship was bimodal (higher risk at both BMI extremes) in infantry Soldiers (20). Body fat did not share the bimodal relationship with injuries in infantrymen (the only MOS where it has been examined in conjunction with injuries); rather, infantrymen with higher body fat were at higher risk and those with lower body fat at lower risk (20). Generally BMI is taken as a marker of body fat since the correlation between these two variables is 0.70 (31-33). However, there was some dissociation of the relationship between BMI and body fat in infantrymen since they did not follow the same relationship with regard to injuries. This difference may be due to the arduous nature of infantry training and the disadvantage that Soldiers with low BMI have in this environment. Soldiers with low BMI have less body mass for their height, reflecting less total body tissue, including lower muscle mass. Infantrymen are frequently engaged in tasks like load carriage, lifting, and carrying and it is possible that those with low BMI might be more susceptible to injury because they have less total tissue over which to spread the load resulting in more stress per unit of total tissue. They may tire more rapidly, resulting in changes in gait and/or specific movement patterns (34-36). This would put unusual stress on portions of the body unaccustomed to this stress, resulting in a higher likelihood of injury. Although military police and armor crewmen perform some tasks that are similar to infantry functions(e.g., physical training, lifting, manual carrying) the nature of their work and

training may be such that low BMI does not increase injury risk; the only increase in risk is at higher BMI levels in these occupational groups.

(5) Low aerobic fitness is a risk factor among infantry Soldiers (19, 20), military police (24), armor crewmen (25) and combat engineers (23). However, when considered in a multivariate analysis with BMI, aerobic fitness remains as an independent risk factor for infantrymen but not for military police or armor crewman (multivariate analyses were not performed on engineers). The fact that 2-mile run time is an independent risk factor for infantrymen may reflect the importance of a high level of aerobic fitness for the tasks performed by Soldiers in this MOS. Although aerobic fitness is still an injury risk factor for military police and armor crewmen, BMI appears to be a more important factor.

(6) Besides low aerobic fitness, low sit-up performance is also an injury risk factor among infantrymen (19, 20). However, there is virtually no relationship between injuries and sit-ups among military police, armor crewmen, or combat engineers (24, 23, 25). This may reflect the importance of abdominal muscular endurance for infantrymen which is possibly related to the rigorous nature of their occupational tasks.

(7) Younger age increases risk in infantry Soldiers (19) but older age increases risk among military police (24) and has less importance for armor crewmen (25). In the infantry, younger Soldiers may perform more of the arduous occupational tasks and thus be more susceptible to injury than older Soldiers who are likely to have higher rank and be in supervisory or staff positions. It is not clear why older Solders were more often injured among military police.

e. *Occupational Tasks of Light-Wheel Vehicle Mechanics*.

(1) An ergonomic analysis was conducted of the occupational tasks performed by Army wheel vehicle mechanics (37). Two steps were involved in the analysis, 1) a review of available documents related to the MOS and 2) interviews with subject matter experts. Documents reviewed included Army regulations, 63B training documents, Army Training and Doctrine Command (TRADOC) documents, and MOS reports. Focus group interviews were conducted with individuals working in the MOS. From a list of the 27 most physically demanding tasks in the MOS (developed from the document review), the mechanics identified the 10 tasks with the highest physical demands. These were 1) replacing a radiator, 2) replacing a starter, 3) correcting a malfunction of a knuckle and geared hub, 4) replacing a half shaft, 5) replacing the front and rear brake pads, 6) replacing universal joints, 7) correcting an alternator malfunction, 8) replacing a propeller shaft, 9) correcting a battery malfunction, and 10) maintaining assigned tool kit.

(2) Informal interviews with Army wheel vehicle mechanics at Fort Bragg, North Carolina indicated that their normal duties involve both normal soldiering activity as well as mechanical work. A typical day in garrison involved morning physical training for about one hour (0630-0730). The Soldiers then had about 1.5 hours for hygiene (showers, clean up) and breakfast (0730-0900). The Soldier reported to the motor pool at 0900. In the motor pool, Soldiers performed mechanical work on vehicles for the remainder of the day which normally lasted from 0900 to 1700. While working in the motor pool mechanics were involved in testing equipment,

troubleshooting, and changing and repairing vehicle parts. Near the end of the work day Soldiers cleaned up the working area. Generally a break was taken about 1200-1300 for lunch. Senior personnel (pay grades E-5 to E-7) spend some time in the shop office doing paperwork while junior personnel (pay grades E-2 to E-4) will typically spend the entire day working in the shop. Besides these typical activities, the Soldiers also had Non-Commissioned Officer Professional Development (NCOPD) classes or tactical training about once a week (1/2 day). Airborne operations were conducted about one time per month or at least once per quarter. On about a quarterly basis, Soldiers were involved in a field training exercise where they spend 3 to 7 days (sometimes longer) in the field. In the field, Soldiers were generally awakened at 0500, do hygiene (clean up, brush teeth, shave), and spent the rest of the day repairing and recovering vehicles. Sleep time in the field was dependent on the amount of equipment that must be repaired. All Soldiers rotated on guard duty both day and night, and the amount of time on guard duty was dependent on the exercise scenario.

f. *Civilian Studies of Auto Mechanics*. Civilian studies of injuries to automotive mechanics are difficult to find because many occupational studies tend to examine broad occupational groups (e.g., services, construction, transportation, etc.) and do not partition out particular specialties. A study examining US industries in 1996 found that the “motor vehicle and car body” industry had the sixth highest incidence rate for nonfatal injury and illness in the US (38). Data on nonfatal occupational injuries and illnesses from the Survey of Occupational Injuries and Illnesses conducted by the US Department of Labor, Bureau of Labor Statistics shows that there were 3.8 cases of occupational injuries and illnesses per 100 “automotive repair and maintenance workers” in 2004 (http://www.bls.gov/iif/home.hym#tables). The cost of fatal and non-fatal occupational injury for automobile mechanics is estimated to be about $65 million per year (direct/indirect cost method), ranking 21st among 419 occupations in the United States (39). A study on mortality among Danish auto mechanics found that mortality due to “external causes” (ICD-9 E-codes E001-E999, primarily accidents and poisoning) was 1.3 times higher than in a comparable occupational group with similar strength/fitness demands, social class, and geographic distribution (carpenters, electricians, instrument makers, dairymen, upholsterers, and glaziers) (40).

4. METHODS. Medical records screening for all 63B Soldiers at Fort Bragg North Carolina was approved by the Womack Hospital Commander, the 82d Airborne Division Surgeon, the US Army Patient Administration Systems and Biostatistical Activity and the Office of the Surgeon General in accordance with Army Regulation 40-66. The 18th Airborne Corps Adjutant General’s office and the 82nd Airborne Division G-1 office provided a list of all Soldiers with an MOS code of 63B who were located at Fort Bragg. These lists were extracted from the Standard Installation Division Personnel System (SIDPERS). This list was sent to the administrators of the 3 health clinics at Fort Bragg (Joel Health Clinic, Clark Health Clinic, Robinson Health Clinic), to the medical records administrator at Womack Army Medical Center, and to the Division Surgeon of the 82d Airborne Division. The medical records administrators and the Division Surgeon arranged to provide the records to the investigators for review.

a. *Injury Data*.

(1) To obtain Soldier injuries, individual medical records (DA Form 3444-6) were examined for each Soldier for the period 1 March 2003 to 29 February 2004 (1 year). For each visit to a medical care provider, extracted information included the date of visit, type of visit (first or follow-up), activity associated with the injury, diagnosis, anatomical location of injury, disposition (final outcome of the visit), and days of limited duty (if any). These data were typically available on one of three forms: 1) Screening Note of Acute Medical Care (Department of the Army Form 5181-R), 2) the Chronology of Medical Care (Standard Form 600), or 3) Emergency Care and Treatment Form (Standard Form 558). Exact medical records screening procedures are at Appendix B. Specific injury diagnoses were developed by Army epidemiologists and clinicians for use in Amy field investigations. The diagnoses were all inclusive and mutually exclusive and could be linked to specific International Classification of Diseases, Version 9 (ICD-9) codes.

(2) There were many injuries for which the medical care provider did not include an activity that was associated with the injury. In these cases, a sheet was made that listed the date of the injury, the diagnosis, and the involved body part. Attempts were made to contact the Soldiers in person (at his/her work site), by phone, or by e-mail to obtain the activity associated with the injury. Soldiers were provided the date of the injury, the diagnosis, and the involved body part and asked how the injury had occurred.

b. *Injury Case Definitions*.

(1) We defined an injury case as a Soldier who sustained physical damage to the body (41) and sought medical care for 1 or more times between 1 March 2003 and 29 February 2004 as recorded in the medical record. Using the diagnosis in the medical records, injuries were grouped by “type” for analysis. “Types” included any injury, overuse injury, traumatic injury, environmental injury, and lower extremity overuse injury. Injury types were determined by the nature of energy exchange and by the specific diagnosis. An overuse injury was presumably due to or related to long-term energy exchanges resulting in cumulative microtrauma. Specific overuse diagnoses included musculoskeletal pain (not otherwise specified), stress fractures, stress reactions, tendinitis, bursitis, fasciitis, overuse syndromes, strains (muscle injury due to overuse), retropatellar pain syndrome, degenerate joint conditions, and shin splints. A traumatic injury was presumably due to sudden energy exchanges resulting in abrupt overload with tissue trauma. Specific diagnoses included pain (due to a traumatic event), sprains, dislocations, fractures, blisters, abrasions, lacerations, strains, and contusions. An environmental injury was due to unusual exposure to chemicals, weather, or animals. Environmental injury diagnoses included heat-related injuries, cold-related injuries, burns, and insect bites. A lower extremity overuse injury was an overuse injury (as defined above) that also involved the lower extremity or lower back. “Any injury” included overuse and traumatic diagnoses as described above. These definitions are consistent with those used in past investigations (9, 13, 14, 16, 42-44).

(2) We examined two “levels” of injury that were assumed to involve different levels of severity. The first level included all visits to a health care provider for any type of injury regardless of whether or not limited duty was prescribed. The second level (a time-loss injury) included only those injuries that resulted in one or more days of limited duty.

(3) By combining injury types and levels we obtained 8 injury measures: any injury, overuse injury, traumatic injury, lower extremity overuse injury, any time-loss injury, time-loss overuse injury, time-loss traumatic injury, and time-loss lower extremity overuse injury. Environmental injuries were not considered in this analysis except in the description of the injury diagnoses.

c. *Physical Characteristics and Ethnicity*. Also extracted from the medical records were date of birth, height, weight, and ethnicity. Date of birth and ethnicity were obtained from the entry physical examination (DA Form 88, Report of Medical Examination), determined on entry to service at the Military Entrance Processing Station (MEPS). Height and weight were obtained from the most recent medical visit that contained that information.

d. *Deployment Data*. Medical records did not contain deployment medical visits and the military units at Fort Bragg had often been deployed to Iraq. Information on Soldier deployments were obtained from the Defense Manpower Data Center. Extracted from this database were the start and end date of any deployments participated in by Soldiers whose medical records had been screened. The number of days deployed within the medical records screening timeframe (1 March 2003 to 29 February 2004) was calculated and designated the deployment time. Deployment time was subtracted from the total time in the study to derive the person-years of exposure

e. *Data Analysis.*

(1) Frequencies were obtained for injury diagnoses, anatomical locations, and activities associated with injury. Descriptive statistics were calculated for the demographic and physical variables. BMI was calculated as body weight/stature^2 (33). Age was calculated as the number of years from the date of birth to 1 March 2003.

(2) To calculate time at risk, the individual Soldier deployment times within the screening timeframe were subtracted from 366 (leap year was included in the project timeframe). Injury incidence rates (injured Soldiers/100 person-years) were calculated as:

Soldiers with ≥1 injury / (total time of all Soldiers adjusted for deployment time) X 100

Injury rates (injuries/100 person-years) were calculated as:

Injuries / (total time for all Soldiers adjusted for deployment time) X 100

Limited duty day rates (days/100 person-years) were calculated as:

Limited duty days / (total time for all Soldiers adjusted for deployment time) X 100

By considering in the numerator only the specific diagnoses noted above in the injury case definitions, injury incidence rates and injury rates were subcategorized into any injury, overuse injury, traumatic injury, lower extremity overuse injury, any time-loss injury, time-loss overuse injury, time-loss traumatic injury, and time-loss lower extremity overuse injury. Limited duty

day rates were similarly subcategorized into any time-loss injury, time-loss overuse injury, time-loss traumatic injury, and time-loss lower extremity overuse injury.

(3) A chi-square test for person-time data was performed to test the hypothesis of no gender difference in injury incidence person-time rates (45).

(4) Cox regression (a survival analysis technique) was used to examine the association between the demographic and physical variables and the time to the first injury. Both non-deployed and deployed Soldiers who were injured had their time censored at the date of the injury. Soldiers who were not deployed within the project timeframe and had no injury in the 1-year timeframe had their entire time considered. Soldiers who were deployed within the project timeframe and were not injured had their time censored on the first day of deployment and were not reentered into the analysis. Soldiers who returned from deployment and had not been previously deployed within the project timeframe were allowed to enter the project at the date they ended their deployment. Univariate Cox regression involved analysis of each of the 8 dependent injury variables with each independent physical or demographic variable. Multivariate analysis included all independent variables with a p-value ≥0.25 (46).

5. RESULTS. SIDPERS data indicated that there were 837 Soldiers with the MOS of 63B on post at Fort Bragg, North Carolina in the 18th Airborne Corps and in the 82d Airborne Division. Of these, 608 medical records were obtained (73%). The major reason for missing medical records was that the SIDPERS rosters were not totally up to date. Accuracy of the SIDPERS rosters was dependent on periodic reports from subordinate units and from the Military Personnel Office (MILPO). Also, the list of 63Bs was requested about two weeks before the list was provided to the clinics, hospital, and aid stations and by this time some Soldiers could have left Fort Bragg for new assignments or might have left the Army. In addition to these factors, some Soldiers had their record in his/her possession (not in the BAS) or their record had been lost. Some medical records contained little information and it was apparent that the Soldier's entire medical history was not included. The most obvious indicator that the record did not contain the entire medical history was that the medical record lacked the DA Form 88, Report of Medical Examination from the MEPS. If this report was missing, the record was considered incomplete. Available data was recorded but that record was not considered for this analysis. There were 47 incomplete records (44 male records and 3 female records). Thus, the final cohort considered for analysis included 518 men and 43 women.

a. *Physical Characteristics and Ethnicity*. Descriptive data on the physical characteristics are shown in Table 3 and ethnicity is described in Table 4. In some of the medical records specific demographic and physical data was missing from the relevant forms. For the male cohort, age was collected on 100% of the Soldiers, height and weight on 96% and ethnicity on 93%. For the female cohort, age, height, and weight were collected on 100% of the Soldiers and ethnicity on 95%.

Table 3. Physical Characteristics of the Soldiers

	Men			Women		
	N	Mean	SD	N	Mean	SD
Age (yrs)	518	27.1	6.8	43	28.1	6.3
Height (in)	498	69	3	43	64	3
Weight (lbs)	498	176	29	43	145	23
BMI (kg/m^2)	498	25.8	3.8	43	24.5	3.2

Table 4. Ethnicity Data on the Soldiers

Ethnicity	Men (n=484)		Women (n=41)	
	N	Proportion of Total (%)	N	Proportion of Total (%)
White	312	64	16	39
Black	107	22	21	51
Other	65	13	4	10

b. *Medical Encounters and Total Injuries*. Men had a total of 1162 medical encounters (visits for injuries, initial and follow-up) while women had a total of 102 medical encounters. Men had a total of 464 injuries and women had a total of 50 injuries (exclusive of follow-ups for previous injuries).

c. *Person-Time and Deployment Time*. The total person-time at risk (non-deployment time) for the men was 132,170 days (361.1 years) with a mean±SD of 255±116 days. The total person-time at risk for the women was 11,764 days (32.1 years) with a mean of 274±111 days. Deployment time for male Soldiers was 57,418 days (156.9 years) and for the female Soldiers 3,974 days (10.9 years). As a group, male Soldiers were deployed 30% of the total survey time while female Soldiers were deployed 25% of the survey time.

d. *Injury Incidence Rates and Injury Rates.*

(1) Table 5 shows the injury incidence rates and compares the male and female rates. The overall injury incidence rate was similar for men and women. However, the overuse rate, lower extremity overuse rate, time-loss overuse rate and time-loss lower extremity overuse rate all tended to be higher in women. On the other hand, the traumatic rate and time-loss traumatic rate tended to be higher among men.

Table 5. Injury Incidence Rates and Gender Comparison of Rates

Measure	Men		Women		Injury Incidence Rate Ratio (Women/ Men)	p-value (men & women)[a]
	Occurrences (n)	Injury Incidence Rate (injured Soldiers/ 100 person-years)	Occurrences (n)	Injury Incidence Rate (injured Soldiers/ 100 person-years)		
Any Injury	260	72.0	26	81.0	1.13	0.57
Overuse Injury	149	41.3	20	62.3	1.51	0.08
Traumatic Injury	158	43.8	10	31.2	0.71	0.29
Lower Extremity Overuse Injury	126	34.9	18	56.1	1.62	0.06
Any Time-Loss Injury	213	59.0	22	68.5	1.16	0.50
Time-Loss Overuse Injury	124	34.3	16	49.8	1.45	0.14
Time-Loss Traumatic Injury	125	34.6	5	15.6	0.45	0.07
Time-Loss Lower Extremity Overuse Injury	105	29.1	15	46.7	1.60	0.09

[a]From Chi square for person-time (45)

(2) Table 6 shows the injury rates and compares the rates by gender. Note that a Soldier could have more than 1 injury so the chi-square for person-time could not be used to compare gender differences because the chi square statistic requires independence in each cell. Overall injury rates (any injury) were higher for the women than for the men. Women had higher rates for overuse injury, lower extremity overuse injury, time-loss overuse injury and time-loss lower

extremity overuse injury. Men had higher injury rates than women for traumatic injury and time-loss traumatic injury.

Table 6. Injury Rates and Gender Comparison of Rates

Measure	Men		Women		Injury Rate Ratio (Women/ Men)
	Occurrences (n)	Injury Rate (injuries/100 person-years)	Occurrences (n)	Injury Rate (injuries/100 person-years)	
Any Injury	448	124.1	50	155.8	1.26
Overuse Injury	220	60.9	34	105.9	1.74
Traumatic Injury	228	63.1	16	49.8	0.79
Lower Extremity Overuse Injury	111	30.7	22	68.5	2.23
Any Time-Loss Injury	301	83.4	32	99.7	1.20
Time-Loss Overuse Injury	145	40.2	22	68.5	1.70
Time-Loss Traumatic Injury	156	43.2	10	31.2	0.72
Time-Loss Lower Extremity Overuse Injury	86	23.8	16	49.8	2.09

e. *Anatomical Locations of Injuries*. Table 7 shows the injuries by anatomical location. For the men, 34% of the injuries occurred in the upper body, 19% in the lower back, and 46% in the lower body. The single sites with the largest proportion of male injuries (in order of incidence) were the low back, knee, and ankle, foot, and shoulder. For women, 24% of the injuries occurred in the upper body, 10% in the lower back and 62% in the lower body. The single sites with the largest proportion of female injuries (in order of incidence) were the knee, low back/foot, ankle, and neck/shoulder.

Table 7. Distribution of Injuries by Anatomical Location

Anatomical Location	Men (n=518)		Women (n=43)	
	Cases (n)	Proportion of All Injuries (%)	Cases (n)	Proportion of All Injuries (%)
Head	11	2.4	1	2.0
Face	5	1.1	0	0.0
Eyes	5	1.1	0	0.0
Neck	19	4.1	3	6.0
Chest	10	2.2	1	2.0
Abdomen	4	0.9	0	0.0
Shoulder	32	6.9	3	6.0
Elbow	8	1.7	1	2.0
Upper Arm	1	0.2	0	0.0
Lower Arm	5	1.1	0	0.0
Wrist	14	3.0	1	2.0
Hand	14	3.0	1	2.0
Finger	20	4.3	0	0.0
Upper Back	9	1.9	1	2.0
Lower Back	87	18.8	5	10.0
Pelvic Area	4	0.9	1	2.0
Hip	5	1.1	2	4.0
Posterior Thigh	5	1.1	0	0.0
Anterior Thigh	5	1.1	0	0.0
Knee	73	15.7	13	26.0
Calf	2	0.4	2	4.0
Shin	19	4.1	2	4.0
Ankle	56	12.1	4	8.0
Foot	34	7.3	5	10.0
Toe	11	2.4	2	4.0
Multiple Areas	4	0.9	1	2.0
Unknown	2	0.4	1	2.0
Total	464	100.0	50	100.0

f. *Injury Diagnoses*. Table 8 shows the distribution of injuries by diagnosis. Many injuries did not have a specific diagnosis but were simply recorded as pain. Overuse injuries accounted for 47% of the male injuries and 68% of the female injuries. Traumatic injuries accounted for 49% of the male injuries and 32% of the female injuries. Environmental injuries made up 3% of the male injuries; women did not have any environmental injuries.

Table 8. Distribution of Injuries by Diagnoses

Diagnoses	Men (n=518)		Women (n=43)	
	Cases (n)	Proportion of All Injuries (%)	Cases (n)	Proportion of All Injuries (%)
Overuse Injuries				
Pain (NOS)[a]	103	22.0	17	34.0
Strain (muscle injury due to overuse)	30	6.5	3	6.0
Tendonitis	23	5.0	1	2.0
Retropatellar Pain Syndrome	15	3.2	2	4.0
Joint-Related Overuse	10	2.2	1	2.0
Stress Fractures/Reactions	8	1.7	1	2.0
Degenerative Joint Conditions	5	1.1	1	2.0
Bursitis	5	1.1	1	2.0
Fasciitis	5	1.1	2	4.0
Shin Splints	4	0.9	3	6.0
Other Overuse	12	2.6	2	4.0
Traumatic Injuries				
Sprain (joint injury associated with trauma)	60	12.9	0	0.0
Pain Associated with Trauma	41	8.8	4	8.0
Contusion	33	7.1	7	14.0
Strain (muscle injury due to trauma)	31	6.7	1	2.0
Abrasion/laceration	22	4.7	2	4.0
Fracture	17	3.7	1	2.0
Other Traumatic Injuries	14	3.0	0	00
Blister	7	1.5	1	1.0
Dislocation	3	0.6	0	0.0
Environmental Injuries				
Insect or animal bite	8	1.7	0	0.0
Heat injury	1	0.2	0	0.0
Contact dermatitis/burns	7	1.5	0	0.0

[a]NOS=Not Otherwise Specified

g. *Activities Associated with Injuries*.

(1) Activities associated with injuries are shown in Table 9. There were 336 of the 464 male injuries (72%) and 36 of the 50 female injuries (72%) that had an associated training event listed in the medical records. An additional 81 male injury activities and 9 female injury activities were obtained by interview. Thus, an associated activity was obtained for 90% of male injuries (417/464) and 90% of female injuries (45/50).

(2) The category that accounted for the largest proportion of injuries was physical training. When sports and physical training were combined, these broad categories of activity were associated with 34% of the male injuries and 32% of the female injuries. Running was associated with 62% of the male physical training injuries (58/93) and 50% of the female physical training injuries (8/16). Of the male sports injuries, basketball was associated with 36% (17/47), football with 21% (10/47), softball with 17% (8/47), and bicycling with 6% (3/47). Of the male mechanical work injuries, activities related to vehicle tires were associated with 14% (7/49), wrenches slipping with 10% (5/49), objects dropped on the body with 10% (5/49), and vehicle starters with 10% (5/49). Of the female mechanical injuries, objects dropped on the body

accounted for 38% (3/8). Most airborne injuries were associated with landing problems, 87% (33/38) for men and 100% (4/4) for women.

Table 9. Distribution of Activities Associated with Injury

Activity	Men			Women		
	Cases (n)	Proportion of All Injuries (n=464) (%)	Proportion of Injuries with Associated Activity (n=417) (%)	Cases (n)	Proportion of All Injuries (n=50) (%)	Proportion of Injuries with Associated Activity (n=45) (%)
Physical Training	93	20.0	22.3	16	32.0	35.6
Mechanical Work	49	10.6	11.8	8	16.0	17.8
Sports	47	10.1	11.3	0	0.0	0.0
Airborne Activity	38	8.2	9.1	4	8.0	8.9
Road Marching	31	6.7	7.4	4	8.0	8.9
Garrison/Home Activity	29	6.3	7.0	4	8.0	8.9
Chronic Conditions	26	5.6	6.2	3	6.0	6.7
Motor Vehicle Accidents	18	3.9	4.3	2	4.0	4.4
Field Training	18	3.9	4.3	1	2.0	2.2
Environmental	11	2.4	2.6	0	0.0	0.0
Fall from Military Vehicle	9	1.9	2.2	0	0.0	0.0
Lifting	9	1.9	2.2	0	0.0	0.0
Getting out of Bed	6	1.3	1.4	0	0.0	0.0
Ice	5	1.1	1.2	0	0.0	0.0
Fighting/Horseplay	4	0.9	1.0	0	0.0	0.0
Other	24	5.2	5.8	3	6.0	6.7
Unknown	47	10.1	0.0	5	10.0	0.0

h. *Limited Duty Day Rates*. The total number of limited duty days and the limited duty day rates are shown in Table 10. Men and women had similar overall rates (any injury). However, overuse and lower extremity overuse rates were higher for women and traumatic rates were much higher for men.

Table 10. Limited Duty Days, Limited Duty Days Rates and Gender Comparison of Rates

Measure	Men		Women		Limited Duty Day Rate Ratio (Women/ Men)
	Limited Duty Days (n)	Limited Duty Day Rate (days/100 person-years)	Limited Duty Days (n)	Limited Duty Day Rate(days/100 person-years	
Time-Loss Injury	7502	2076	631	1966	0.95
Time-Loss Overuse Injury	4203	1164	549	1710	1.47
Time-Loss Traumatic Injury	3299	914	82	255	0.28
Time-Loss Lower Extremity Overuse Injury	3414	945	489	1523	1.61

i. *Injury Risk Factors.*

(1) Because of the small number of women, Cox regressions were only performed on the men. Any attempt to develop female risk subgroups for the Cox regressions would have resulted in very small numbers of women in each subgroup which would have severely limited statistical power.

(2) Table 11 shows the univariate Cox regression results for any injury and any time-loss injury. There was increased risk of injury with greater body weight or higher BMI.

(3) Table 12 shows the univariate Cox regression results for overuse injuries and time-loss overuse injuries. Greater body weight and higher BMI were associated with injury risk. The

oldest age group (>35 years) was at higher injury risk compared to the youngest age group (18-25 year olds). Those of other ethnicity, were also at higher injury risk, compared to Whites

(4) Table 13 shows the univariate Cox regression results for traumatic injuries and time-loss traumatic injuries. Greater body weight and higher BMI were traumatic injury risk factors. The highest age group was at somewhat higher injury risk.

(5) Table 14 shows the univariate Cox regression results for lower extremity overuse injuries and time-loss lower extremity overuse injuries. Results were similar to those of overuse injury. Greater body weight and higher BMI were injury risk factors. The oldest age group tended to be at higher injury risk than the youngest age group.

(6) Multivariate Cox regressions are shown in Tables 15 to 18. Blank cells in these tables indicate that the particular variable did not meet the criteria described in the Data Analysis section for entry into the multivariate model. Since BMI is calculated from weight, the two variables would normally be expected to be collinear and this suspicion was supported in the univariate analysis since both variables were similarly associated with injury risk. BMI was selected for the multivariate analysis.

(7) Table 15 shows the multivariate Cox regression results for any injury and any time loss injury. BMI was significantly associated with any injury risk. The 30 to 35 year olds were at lower injury risk than the youngest age group. For any time-loss injury only BMI met the criterion for entry into the multivariate model and the results only repeat that of the univariate analysis.

Table 11. Univariate Cox Regression Results for Any Injury and Any Time-Loss Injury (Men)

Variable	Level of Variable	N	Any Injury			Any Time-Loss Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	1.02	0.72-1.48	0.88	1.09	0.73-1.63	0.69
	30.1-35.0	84	0.87	0.62-1.25	0.45	0.95	0.64-1.42	0.81
	>35.0	84	1.23	0.88-1.71	0.23	1.19	0.82-1.73	0.35
Height	57-66 in	130	0.91	0.64-1.29	0.63	0.81	0.55-1.20	0.30
	67-69 in	135	0.82	0.57-1.14	0.21	0.84	0.57-1.23	0.37
	70-71 in	116	1.08	0.76-1.53	0.67	1.01	0.69-1.49	0.95
	72-80 in	117	1.00	---	---	1.00	---	---
Weight	114-154 lbs	129	1.00	---	---	1.00	---	---
	155-172 lbs	123	1.60	1.08-2.37	0.02	1.95	1.23-3.09	<0.01
	173-193 lbs	128	2.18	1.50-3.19	<0.01	2.78	1.78-4.32	<0.01
	194-270 lbs	118	2.01	1.38-2.95	<0.01	2.57	1.64-4.03	<0.01
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	1.71	1.16-2.51	<0.01	1.81	1.15-2.83	<0.01
	25.8-28.1 kg/m^2	123	2.35	1.60-3.46	<0.01	2.57	1.66-3.97	<0.01
	28.2-38.0 kg/m^2	123	2.00	1.36-2.95	<0.01	2.31	1.48-3.58	<0.01
Ethnicity	White	311	1.00	---	---	1.00	---	---
	Black	107	0.97	0.70-1.32	0.82	0.94	0.66-1.34	0.74
	Other	66	1.21	0.84-1.75	0.31	1.21	0.81-1.80	0.35

Table 12. Univariate Cox Regression Results for Overuse Injury and Time-Loss Overuse Injury (Men)

Variable	Level of Variable	N	Overuse Injury			Time-Loss Overuse Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	1.16	0.71-1.88	0.56	1.04	0.60-1.79	0.90
	30.1-35.0	84	0.95	0.59-1.55	0.84	0.89	0.52-1.51	0.66
	>35.0	84	1.66	1.09-2.25	0.02	1.57	1.00-2.48	0.05
Height	57-66 in	130	0.74	0.46-1.18	0.20	0.75	0.44-1.27	0.28
	67-69 in	135	0.74	0.46-1.17	0.11	0.82	0.49-1.37	0.45
	70-71 in	116	1.10	0.71-1.72	0.66	1.23	0.75-2.00	0.41
	72-80 in	117	1.00	---	---	1.00	---	---
Weight	114-154 lbs	129	1.00	---	---	1.00	---	---
	155-172 lbs	123	1.65	0.97-2.81	0.07	1.98	1.06-3.68	0.03
	173-193 lbs	128	2.34	1.41-3.90	<0.01	2.91	1.60-5.25	<0.01
	194-270 lbs	118	2.20	1.31-3.68	<0.01	2.67	1.46-4.88	<0.01
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	1.19	0.71-1.99	0.51	1.46	0.88-2.61	0.20
	25.8-28.1 kg/m^2	123	1.85	1.13-3.02	0.01	2.04	1.16-3.56	0.01
	28.2-38.0 kg/m^2	123	1.82	1.12-2.96	0.02	2.05	1.18-3.57	0.01
Ethnicity	White	311	1.00	---	---	1.00	---	---
	Black	107	0.94	0.61-1.45	0.77	0.98	0.61-1.57	0.92
	Other	66	1.48	0.94-2.33	0.09	1.69	1.05-2.73	0.03

Table 13. Univariate Cox Regression Results for Traumatic Injury and Time-Loss Traumatic Injury (Men)

Variable	Level of Variable	N	Traumatic Injury			Time-Loss Traumatic Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	0.77	0.47-1.24	0.29	0.91	0.54-1.54	0.75
	30.1-35.0	84	0.83	0.52-1.33	0.44	0.98	0.59-1.64	0.94
	>35.0	84	1.42	0.93-2.19	0.11	1.55	0.96-2.50	0.07
Height	57-66 in	130	1.15	0.74-1.79	0.52	1.08	0.66-1.77	0.76
	67-69 in	135	0.85	0.54-1.35	0.49	0.92	0.56-1.52	0.74
	70-71 in	116	0.99	0.62-1.55	0.92	0.84	0.49-1.42	0.51
	72-80 in	117	1.00	---	---	1.00	---	---
Weight	114-154 lbs	129	1.00	---	---	1.00	---	---
	155-172 lbs	123	1.45	0.89-2.35	0.13	1.85	1.04-3.29	0.04
	173-193 lbs	128	1.80	1.13-2.88	0.01	2.26	1.29-3.96	<0.01
	194-270 lbs	118	1.41	0.86-2.30	0.17	1.87	1.04-3.34	0.04
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	1.79	1.10-2.91	0.02	1.95	1.09-3.50	0.02
	25.8-28.1 kg/m^2	123	1.93	1.17-3.16	0.01	2.21	1.23-3.95	<0.01
	28.2-38.0 kg/m^2	123	1.68	1.02-2.78	0.04	2.27	1.27-4.04	<0.01
Ethnicity	White	311	1.00	---	---	1.00	---	---
	Black	107	0.87	0.58-1.31	0.50	0.78	0.49-1.25	0.30
	Other	66	1.13	0.71-1.80	0.60	1.05	0.62-1.77	0.87

Table 14. Univariate Cox Regression Results for Lower-Extremity Overuse Injury and Time-Loss Lower Extremity Overuse Injury (Men)

Variable	Level of Variable	N	Lower Extremity Overuse Injury			Time-Loss Lower Extremity Overuse Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	1.14	0.67-1.93	0.64	1.07	0.61-1.89	0.81
	30.1-35.0	84	0.80	0.46-1.38	0.42	0.73	0.40-1.34	0.31
	>35.0	84	1.51	0.96-2.39	0.08	1.36	0.83-2.25	0.23
Height	57-66 in	130	0.75	0.45-1.24	0.26	0.73	0.42-1.25	0.24
	67-69 in	135	0.66	0.40-1.09	0.11	0.64	0.37-1.11	0.11
	70-71 in	116	1.02	0.63-1.65	0.96	0.98	0.58-1.65	0.94
	72-80 in	117	1.00	---	---	1.00	---	---
Weight	114-154 lbs	129	1.00	---	---	1.00	---	---
	155-172 lbs	123	1.43	0.80-2.58	0.23	1.49	0.77-2.87	0.24
	173-193 lbs	128	2.25	1.30-3.89	<0.01	2.53	1.38-4.63	<0.01
	194-270 lbs	118	2.15	1.24-3.76	<0.01	2.34	1.27-4.34	<0.01
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	0.99	0.56-1.74	0.96	1.07	0.58-1.97	0.84
	25.8-28.1 kg/m^2	123	1.70	1.01-2.86	0.05	1.60	0.90-2.86	0.11
	28.2-38.0 kg/m^2	123	1.73	1.04-2.92	0.04	1.85	1.05-3.25	0.03
Ethnicity	White	311	1.00	---	---	1.00	---	---
	Black	107	0.85	0.53-1.36	0.49	0.91	0.55-1.53	0.73
	Other	66	1.12	0.66-1.89	0.68	1.47	0.88-2.51	0.14

(8) Table 16 shows the multivariate Cox regression results for overuse injury and time-loss overuse injury. For overuse injury, BMI is associated with injury and the 30 to 35 year olds have lower injury risk than the youngest age group. For time-loss overuse injury, BMI and other ethnicity (compared to Whites) are associated with injury while there is a weak trend for the oldest age group to have higher injury risk.

(9) Table 17 shows the multivariate Cox regression results for traumatic injury and time-loss traumatic injury. BMI is associated with both types of injuries. Soldiers 25 to 35 years old appear to be at reduced traumatic injury risk compared to the youngest age group.

(10) Table 18 shows the multivariate Cox regression results for lower extremity overuse injury and time-loss lower extremity overuse injury. High BMI is a significant risk factor and there is a weak trend for the 30 to 35 year olds to be at lower injury risk than the youngest age group.

Table 15. Multivariate Cox Regression Results for Any Injury and Any Time-Loss Injury (Men)

Variable	Level of Variable	N	Any Injury			Any Time-Loss Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---			
	25.1-30.0	73	0.93	0.65-1.35	0.71			
	30.1-35.0	84	0.68	0.46-1.00	0.05			
	>35.0	84	0.97	0.69-1.37	0.86			
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	1.74	1.18-2.57	<0.01	1.95	1.23-3.09	<0.01
	25.8-28.1 kg/m^2	123	2.58	1.73-3.85	<0.01	2.78	1.78-4.32	<0.01
	28.2-38.0 kg/m^2	123	2.09	1.40-3.11	<0.01	2.57	1.64-4.03	<0.01
Ethnicity	White	311						
	Black	107						
	Other	66						

Table 16. Multivariate Cox Regression Results for Overuse Injury and Time-Loss Overuse Injury (Men)

Variable	Level of Variable	N	Overuse Injury			Time-Loss Overuse Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	1.05	0.71-1.56	0.80	0.98	0.54-1.76	0.94
	30.1-35.0	84	0.68	0.46-1.02	0.06	0.73	0.41-1.31	0.29
	>35.0	84	1.13	0.78-1.65	0.52	1.33	0.80-2.21	0.28
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	1.65	1.10-2.48	0.02	1.48	0.80-2.73	0.21
	25.8-28.1 kg/m^2	123	2.37	1.56-3.59	<0.01	2.20	1.20-4.04	0.01
	28.2-38.0 kg/m^2	123	2.00	1.32-3.02	<0.01	1.97	1.08-3.58	0.03
Ethnicity	White	311	1.00	---	---	1.00	---	---
	Black	107	0.84	0.60-1.18	0.32	0.89	0.54-1.47	0.65
	Other	66	1.16	0.80-1.68	0.44	1.62	0.99-2.64	0.05

Table 17. Multivariate Cox Regression Results for Traumatic Injury and Time-Loss Traumatic Injury (Men)

Variable	Level of Variable	N	Traumatic Injury			Time-Loss Traumatic Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	0.60	0.36-0.99	0.04	0.67	0.39-1.17	0.16
	30.1-35.0	84	0.66	0.40-1.08	0.10	0.77	0.45-1.33	0.35
	>35.0	84	1.33	0.86-2.05	0.20	1.44	0.88-2.33	0.14
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	1.95	1.19-3.18	<0.01	2.10	1.17-3.76	0.01
	25.8-28.1 kg/m^2	123	2.22	1.33-3.69	<0.01	2.42	1.33-4.40	<0.01
	28.2-38.0 kg/m^2	123	1.96	1.17-3.28	0.01	2.54	1.40-4.60	<0.01
Ethnicity	White	311						
	Black	107						
	Other	66						

Table 18. Multivariate Cox Regression Results for Lower-Extremity Overuse Injury and Time-Loss Lower Extremity Overuse Injury (Men)

Variable	Level of Variable	N	Lower Extremity Overuse Injury			Time-Loss Lower Extremity Overuse Injury		
			Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
Age	18.1-25.0	277	1.00	---	---	1.00	---	---
	25.1-30.0	73	0.98	0.58-1.68	0.95	0.99	0.54-1.83	0.98
	30.1-35.0	84	0.64	0.36-1.13	0.13	0.59	0.31-1.14	0.12
	>35.0	84	1.16	0.72-1.89	0.54	1.14	0.65-2.01	0.65
BMI	16.0-23.3 kg/m^2	124	1.00	---	---	1.00	---	---
	23.4-25.7 kg/m^2	128	0.98	0.56-1.74	0.95	1.09	0.58-2.08	0.80
	25.8-28.1 kg/m^2	123	1.82	1.06-3.14	0.03	1.81	0.96-3.40	0.07
	28.2-38.0 kg/m^2	123	1.74	1.01-3.00	0.04	1.89	1.03-3.47	0.04
Ethnicity	White	311				1.00	---	---
	Black	107				0.85	0.49-1.47	0.56
	Other	66				1.43	0.83-2.42	0.20

(11) Because the relationships between injury and age and injury and ethnicity were considerably weakened when considered in a multivariate model with BMI, the association between BMI and age, and BMI and ethnicity was examined. As shown in Table 19, those of Black and Other ethnicity had higher BMI values than Whites. BMI progressively increased with age.

Table 19. Male BMI Values by Ethnicity and Age Group

Variable	Level of Variable	Mean	SD	p-value[a]
Ethnicity	White	25.4	3.5	<0.01
	Black	26.5	4.1	
	Other	26.8	4.4	
Age Group	17.0-25.0 years	24.8	3.5	<0.01
	25.1-30.0 years	25.9	3.6	
	30.1-35.0 years	26.8	3.4	
	>35.0 years	27.8	4.1	

[a]From independent sample t-test

6. DISCUSSION. This investigation found that the overall injury rate among wheel vehicle mechanics was about 127 injuries/100 person-years (men and women combined). Each year an average of about 20 days of limited duty were prescribed per mechanic. The largest proportions of injuries were experienced in the lower back, knee, and ankle areas. Physical training and mechanical work were the two activities associated with the highest proportion of the injuries. Among men, greater BMI and higher body weight were associated with higher injury risk regardless of the injury definition. In univariate analysis, older age and "Other" ethnicity were associated with overuse injury but these relationships were substantially weakened when considered in a multivariate model with BMI. BMI systematically varied with age and was greater in Blacks and those of "Other" ethnicity, compared to Whites.

a. *Gender Differences.*

(1) Some gender differences emerged among the mechanics but the small number of women suggests a cautious approach in examining these differences. While men had about an equal number of traumatic and overuse injuries, almost 70% of female injuries were in the overuse category. A large portion of the total injuries involved the lower body/low back areas in both genders but the women had a larger proportion of injuries in these areas (72% vs. 65%). This is the first paper to report on comparative injury rates of men and women in the same MOS so there are no previous studies to use for comparison. BCT/AIT studies generally agree with the results reported here showing that compared to men, women have a larger proportion of overuse and lower extremity overuse injuries (9, 17, 47, 48).

(2) Much of the higher overuse injury rate in women was accounted for by a higher proportion of pain, not otherwise specified (NOS) making it difficult to interpret this gender difference. Examination of gender differences in pain, NOS, by activity associated with injury or by anatomical location did not provide any additional insight. For pain NOS, physical activity was associated with 29% of the incident injuries in both men and women while "unknown" activities accounted for 21% of the male and 18% of the female incident injuries. With regard to anatomical location, 47% of the male pain NOS incident injuries occurred in the lower back while 24% of the female pain NOS incident injuries were in this location; 18% of the male pain NOS occurred in the knee while 24% of the female injuries were in this location.

(3) Almost 20% of the men's injuries were diagnosed as traumatic sprains (12.9%) and strains (6.7%) while women had no traumatic sprains and only a single traumatic strain (2%). Seventy-seven percent of the male sprains involved the ankle. Activities associated with these sprains included physical training (23%), airborne ground landings (10%), basketball (10%), home/garrison activity (10%), and motor vehicle accidents (7%). For male strains, 37% involved the low back,13% the neck, and 10% the posterior thigh (hamstring area). Activities associated with these male strains included physical training (20%), airborne ground landings (17%), road marching (10%) and field training (5%). The single female strain involved the neck in a motor vehicle accident.

(4) The study by Tomlinson et al. (29) examining injuries among Soldiers at Fort Lewis, Washington used an injury case definition that involved primarily traumatic injuries (i.e., fractures, sprains, dislocations, lacerations, abrasions, contusions, low back strains, eye injury,

internal injury of the head, chest, abdomen, heat/cold injury). They found that men were 1.20 (95%CI=1.1-1.4) times more likely to be injured than women (secondary data analysis). This generally agrees with the results reported here in which male mechanics experienced a traumatic injury rate that was 1.27 times higher than that of the female mechanics. Some studies have shown that compared to women, men and male adolescents are more likely to engage in risk taking behavior and/or report higher scores on tests designed to measure risk-taking behavior (49-53), although there is some contradictory evidence (54). Risk-taking behaviors may be more likely to result in traumatic (acute) injuries due to a sudden overload event (falls, stepping into a hole, tripping, etc.). Overuse injuries are due primarily to the repetitive use of a body part and the female mechanics were more susceptible to injuries of this type.

b. *Injury Rates*. Table 20 is a partial repeat of a similar table in the Background section of this paper (Table 2) but includes results from the present project. As noted above, Tomlinson et al. (29) used a considerably different injury case definition than most other studies cited in this table. For studies that used a similar injury case definition (19-22, 24, 25), it can be seen that the injury rates of the male mechanics were similar to those of the infantry and military police. The yearly number of limited duty days for the mechanics was second only to the military police.

Table 20. Comparison of Injury Rates and Clinic Visit Rates of US Army Soldiers in Various MOSs

Study	Year Data Collected	Type of Unit	Rate (events/100 person-months)		Limited Duty (days/100 person-years)[c]
			Injuries[cd]	Clinic Visits for Injuries[c]	
Tomlinson et al. (29)[a]	1984-1985	Infantry Infantry Special Forces Rangers Aviation/Artillery	12.2 18.6 12.1 10.1 4.5	ND ND ND ND	ND ND ND ND
Knapik et al. (19)[b]	1989	Infantry	11.8	18.3	1184
Reynolds et al. (20)	1989-1990	Infantry	ND	15.1	609
Reynolds et al. (22)	1996	Combat Engineers Artillery	ND ND	16.8 12.3	594 574
Smith and Cashman (21)	1997-1998	Infantry	8.4	ND	1573
Hauret et al. 24	2002	Military Police	9.2	19.2	3250
Darakjy et al. 25	2002	Armor	5.7	11.0	1580
Present Project	2004	Wheel Vehicle Mechanics	Men 10.3 Women 13.0	Men 18.6 Women 19.8	Men 2076 Women 1966

[a]Originally based on 8 weeks of data collection
[b]Originally based on 6 months of data collection
[c]ND=No data
[d]A single Soldier could have more than one injury.

c. *Anatomical Locations*.

(1) A few investigations of specific MOSs have partitioned injuries by anatomical location (19-21). Table 21 shows these studies along with the results of the current project. Of the 3 major body areas, (upper body, lower body, lower back), male and female mechanics have the largest proportion of their injuries in the lower body in consonance with the other MOSs However, male mechanics have more of their injuries in the upper body than any other MOSs Upper body injuries among the male mechanics are not localized to any one particular upper body area but rather distributed to the face (5%), neck (4%), chest (2%), abdomen (1%), shoulders (7%), upper back (2%), and upper extremities (13%).

Table 21. Comparison of Studies by Anatomic Location (numbers are % of total injuries)

Anatomical Location	Smith and Cashman (21) – Infantry	Knapik et al. (19) –Infantry	Reynolds et al (20)		Present Project - Wheel Vehicle Mechanics	
			Engineers	Artillery	Men	Women
Lower Body	61.3	58.2	67.8	47.3	46.1	62.0
Knee	18.0	11.8	No Data	No Data	15.7	26.0
Ankle	13.7	13.2	7.4	4.4	12.1	8.0
Foot	16.7	16.1	12.8	8.9	7.3	10.0
Upper Body	22.0	28.8	18.8	24.6	33.8	24.0
Shoulder	6.2	3.3	No Data	No Data	6.9	6.0
Extremities	9.7	13.2	12.8	13.8	13.4	6.0
Lower Back	11.6	7.1	13.4	28.1	18.8	10.0
Other	5.1	5.9	0.0	0.0	1.2	4.0

(2) As noted previously, mechanics have a high rate of disability associated with back problems. Mechanics rank 3rd (women) and 9th (men) among all MOSs in back disability cases (28). In the present project, upper and lower back problems accounted for 21% of the male injuries and 12% of the female injuries.

d. *Activities Associated with Injuries.*

(1) Very few investigations have reported activities associated with injuries despite the importance of this information for intervention efforts. One reason activities associated with injury are often not reported is that the data is difficult to obtain. Medical care professionals often do not record these data in the medical records. In the present project, 28% of the injuries had no associated event. We were able to make personal contact with some of the Soldiers to obtain an associated training event on an extra 18% of the injuries, resulting in a 90% capture rate. A second reason it is difficult to obtain associated training events is that a Soldier may not recall how or when the injury occurred. Further, there may not have been a proximate event because the pain came on gradually over time. Some caution is called for in interpreting the data because Soldiers may report an event that was not the "cause" of the injury but rather the event that aggravated the injury and caused the pain.

Table 22. Major Activities Associated with Injury in Various Investigations (numbers are % of total activities)

	Smith and Cashman (21) – Infantry	Hauret et al. (24) – Military Police	Present Project – Wheel Vehicle Mechanics	
			Men	Women
Physical Training	49.6	39.1	22.3	32.0
Sports	8.0	17.2	11.3	0.0
Road Marching	15.6	---	7.4	8.9
Job/Field[a]	13.6	29.9	27.8[a]	28.9[a]

[a]Combines categories of mechanical work, garrison/home activity, field training, environmental, and falls from military vehicles

(2) Table 22 shows studies that examined activities associated with injuries in various MOSs. The four broad categories in the table account for 87% of the infantry injuries, 86% of the military police injuries, and about 70% of injuries among wheel vehicle mechanics. Across all these MOSs, physical training has been shown to be the activity that is associated with the largest single proportion of injuries. The single physical training activity that seems most associated with injury is running. In the present project running alone was associated with 14% (58/417) of all male injuries and 18% (8/45) of all female injuries (denominators are injuries with associated training event). In a previous study of ordnance school students in AIT, running was associated with 45 to 49% of all injuries (55). Running is a popular physical training exercise in the military (56) and is performed on a regular basis by individual Soldiers and in

military units that have organized physical training. The 2-mile run is an Army Physical Fitness Test (APFT) event for which all Soldiers must meet certain age and gender adjusted standards on a twice yearly basis. Both civilian (57-61) and military (16, 62, 63) investigations have shown that as the volume of running increases so does the incidence of injury. Targeted reductions in running mileage have been shown to reduce injury risk without having significant effects on aerobic fitness improvements (64-66).

(3) Mechanical work was the second activity most associated with injury among the mechanics. This category accounted for a larger proportion of the female injuries than the male injuries (18% vs 12%). Based on an analysis of the critical tasks performed by mechanics (37), it was found that much of the occupational work involves the upper body and low back in the use of hand tools (torque applied to tools like wrenches and screwdrivers), and for removing and replacing (lifting) vehicle parts like radiators, fuel pumps, alternators, batteries, starters, brakes, tires, axles, wheels and hubs. A closer examination of these tasks with a view to reduce injuries could develop some helpful interventions.

(4) Sports activity accounted for the third largest proportion of injuries. This was associated with 11% of the male injuries but women did not have any sports injuries. Basketball was the sport most commonly associated with injury and accounted for 4% of all injuries. Prophylactic ankle bracing has been shown to reduce the incidence of basketball ankle injuries (67). High- top basketball shoes do not appear to influence injury rates among basketball players (68).

(5) Landings in association with airborne operations accounted for the fourth largest proportion of injuries, 9% of both the male and female injuries. About 26% (11/42) of these injuries involved the ankle which is somewhat lower than the 32 to 41% reported in other studies of airborne operations (69-72). Outside-the-boot ankle braces have been shown to reduce the incidence of ankle injuries during airborne operations (73-75). The use of ankle braces on airborne operations was required from 1994 to 2001 but ankle braces were discontinued in 2001 because of cost considerations and anecdotal reports that they caused other types of injuries (74). Ankle braces were reinstated in 2005 as a result of a mandate from the Defense Safety Oversight Council (DSOC) and this should assist in reducing injuries.

e. *BMI and Injury*.

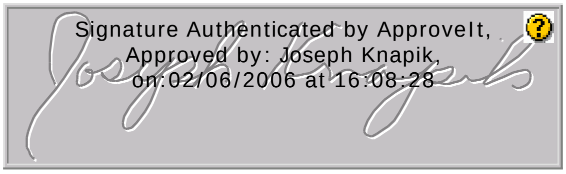
(1) Higher BMI was associated with higher injury risk among the men in the present project. In consonance with these data, higher BMI was also an injury risk factor in studies on military police, armor crewmen, infantrymen, and combined combat engineers and artillerymen (20, 22, 24, 25). For infantrymen, the relationship between BMI and injury risk was bimodal (higher injury risk at both high and low levels of BMI) (20).

(2) Many studies have used BMI as a marker of overweight and obesity (76-82). There are several advantages to the use of this index. BMI "corrects" body weight for the height of an individual, essentially removing the dependency of weight on height (32). BMI is easy to obtain and the large databases cited above can be used to describe populations and trends. The correlation between body fat and BMI is about 0.7 in both civilian samples (31, 32) and in

military recruits (33). However, a correlation of 0.7 indicates that only about ½ of the variance in BMI is accounted for by body fat. There is evidence that BMI may be associated with different proportions of body fat in different racial groups and that leg length and body build can affect the association between fat and BMI (83). An individual can have a high BMI because of a high proportion of any tissue in the body, not just fat (e.g., bone, muscle).

(3) Thus, some caution is called for in relating BMI to body fat. Despite this, the data does suggest that individuals that carry more body weight for their height are at higher injury risk. The greater weight may result in greater forces on body tissues during physical activity (physical training and occupational tasks) resulting in a greater likelihood of injury.

7. CONCLUSIONS. This project identified injury rates, types of injuries, anatomical locations of injuries, activities associated with injuries, and some injury risk factors among Army wheel vehicle mechanics. Women had a higher overall injury rate than men (156 versus 124 injuries/100 person-years). Most of the higher overall injury rate of the women was due to overuse injuries; men had a higher traumatic injury rate. The average mechanic had about 20 days of limited duty each year. The largest proportions of injuries were experienced in the lower back, knee, and ankle areas. Physical training and mechanical work were the two activities associated with the highest proportion of the injuries. Among men, greater BMI was associated with a higher likelihood of injury.



JOSEPH J. KNAPIK
Research Physiologist

Approved:

BRUCE H. JONES
Program Manager, Injury Prevention

APPENDIX A
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APPENDIX B
Instructions and Conventions for Medial Records Screening

Enter the following one time for each medical record

Gender: Gender can be found in the initial entry physical exam at the back of the medical record but also on the sick call notes and other places in the medical record.

0=Man
1=Woman
99=Unknown

DoB: Date of Birth. This can be found on the initial entry physical exam form at the back of the medical record. Format is DD-MMM-YY.

Company: Enter only the first character (A,B,C,D,E, etc)

Battalion: Enter the battalion to which the soldier belongs.

Ethnicity: Enter from most recent Physical Examination Form.

1=White, non-Hispanic
2=Black, non-Hispanic
6=Other
7=unknown

Height: Enter height in **inches** from the most recent physical exam. Round to the nearest whole number (i.e. 70-1/4" =70"; 54-3/4"=55")

Weight: Enter height in **pounds** from the most recent physical exam. Round to the nearest whole number.

Physical Date: Enter the date of the most recent physical exam from which the height and weight were obtained.

Enter the following for each recorded injury visit the soldier has made in the last year:

Date of visit: Enter two digit day, month, and year of visit in military format (DD-MMM-YY).

Fort Bragg Visit: Enter whether or not visit occurred at Fort Bragg.

0=No
1=Yes
99=Unknown

Follow-up: "No" indicates a first visit for this condition; "yes" indicates a follow-up visit (subject was seen previously for this condition). Default is "no".

0=No
1=Yes
99=Unknown

Associated Training Event: Training event associated with the injury (if any). Only enter this for the initial visit. Do not enter for follow-up visits. Associated training event is usually found in the subjective of the SOAP profile. Sometimes the training event is listed with a follow-up visit but the associated training event should still be listed on the initial visit line.

0=Not Applicable
1=Physical Training (PT)
2=APFT
3=Sports
4=Motor Pool
5=Tracked Vehicle (military)
6=Wheeled Vehicle (military)
7=POV
8=Road March
9=Marching
10=Field training
11=Artillery
12=Range activity
13=Airborne Jump
14=Garrison activity
98=Other
99=Unknown

Mechanism Notes: Enter a more detailed description of the injury mechanism. Record exactly what is in the medical record.

Diagnosis: Choose one of the following diagnoses from the drop box:

Code	Abbreviation	Description
0	NV	No Visits
Overuse injuries:		
1	STR_FX	Stress fractures
2	STR_RXN	Stress reaction
3	TND	Tendinitis
4	DJD	Degenerative Joint Disease
5	BURS	Bursitis
6	FASC	Fasciitis
7	RPPS	Retropatellar pain syndrome
8	IMP	Impingement
9	STRAIN_OU	Muscle injury, not involving joint, due to overuse
10	SPRAIN_OU	Joint injury due to overuse
11	PAIN_OU	Musculoskeletal pain due to overuse
12	OTH_OU	Overuse injury, other

13	SHIN_SPL	Shin Splints
Traumatic injuries:		
14	SPRAIN_TR	Joint injury due to traumatic event
15	STRAIN_TR	Muscle injury, not involving joint, due to a traumatic event
16	PAIN_TR	Musculoskeletal pain due to traumatic event
17	DISLOCN	Dislocation
18	FRACT	Fracture
19	BLISTER	Blister
20	ABRSN_LC	Abrasion or laceration
21	CONTSN	Contusion
22	OTH_TI	Other traumatic injury
23	OTH_MS	Other musculoskeletal injury, not listed
Environmental Injuries:		
24	HEAT	Heat-related injury or illness (e.g., heat exhaustion, heat stroke, dehydration)
25	COLD	Cold-related injury or illness (e.g., frostbite, hypothermia)
26	BITE_IN	Insect bites or stings
27	BITE_AN	Animal or snake bite
28	OTH_ENV	Other, environmental/toxic injury
29	NEURO	Neurological
97	NORMAL	Normal exam-nothing found
98	OTH_INJ	Other injury
99	UNK	Unknown

Diagnosis Comments: Enter a more detailed description of the diagnosis. Record exactly what is in the medical record.

Body part injured: This is typically given with the diagnosis.

0=NA (not applicable)
1=HEAD
2=FACE
3=EAR
4=EYE
5=NECK
6=CHEST
7=ABDOMEN
8=UP_BACK
9=LO_BACK
10=SHOULDER
11=ELBOW
12=UP_ARM
13=LO_ARM
14=WRIST

15=HAND
16=FINGER
17=PELVIC REGION
18=HIP
19= POSTERIOR THIGH (Hams)
20=ANTERIOR THIGH (Quads)
21=KNEE
22=CALF
23=SHIN
24=ANKLE
25=FOOT
26=TOE
27=MULTIPLE
98=OTHER
99=UNKNOWN

Disposition: Final outcome of the injury visit as assigned by the medical provider. If the provider issued both a consult and a profile, list the profile.

0=Not Applicable
1=Returned to Duty (no profile)
2=Profile (Returned to Duty)
3=Quarters
4=Hospitalized
5=Consult
6=Permanent Profile
98=Other
99=Unknown

Days of limited duty: Enter the number of days of limited duty given to the soldier. Enter zero if no days of limited duty are given. Days of limited duty is typically found with the disposition. Default (unknown) = 99.

Additional Notes (circumstances): Enter miscellaneous notes on events surrounding the occurrence of the injury or illness.

MEDICAL RECORD DATA ENTRY CONVENTIONS

1. **Order of Listing Medical Visits.** Start at the back of the record and work forward chronologically. Go back to one year from the date of the start of medical records screening.

2. **Rounding Numbers**. For any numerical data (duration, days of limited duty), always round up. For example, 1-1/2 weeks=11 days.

3. **Changing Diagnosis.** Diagnosis may change as the individual gets to a higher level of medical care. Record diagnosis at highest level of care as the first diagnosis. The first diagnosis often has to be corrected because on follow up, more tests are completed and more definitive diagnoses are developed.

4. **Single Visit, Two Injuries**. If there are two problems during a single visit, list only the major problem/diagnosis. In general, the major problem is what brought the person to the clinic. There may be an opportunity to list the second problem as an initial visit on a subsequent visit.

5. **Screening Tests.** Visits to the clinic for “screening tests” are not entered (e.g., screening for eyeglasses, respiratory test for gas mask, etc.). The individual did not voluntarily come in for a medical problem in this case but rather was required to come in.

6. **Rule Out Diagnoses**. If the diagnosis includes “rule out” (R/O), go forward in the medical record to see if the condition was, in fact, ruled out. If not, enter the R/O as the diagnosis.

7. **Stress Fractures/Stress Reactions.** For suspected stress fractures/stress reactions examine the radiology report. If it is positive for stress fractures, diagnosis is recorded as a stress fracture. If radiology is negative but symptoms are present, record it as a stress reaction.

8. **Always Complete Diagnosis Comments.** Always fill in “Diagnosis Comments” field even if it just repeats a coded diagnosis. Fill this in exactly as shown in the medical record, without interpretation. Filling in assures the data analyst you did not just miss the field.

9. **Follow-ups without Initial Visits.** If a visit is a follow up but there is no initial visit in the record, list the follow up as an initial visit. This is so the visit is not missed in the initial visit count.

10. **Overlapping Profiles in Days of Limited Duty**. In the absence of any other indicator in the medical record, do not add overlapping profile days. If a soldier receives additional profile days while still on a profile, enter only those days above and beyond what is left on the soldier’s original profile.

11. **Always list profiles**. No matter what the final disposition is, always list the profile and the profile days if a profile is given. Thus, if the provider gives the soldier a profile and sends him or her for a consult, list the profile rather than the consult.

12. **Determining Follow-ups**. In the absence of any other indicator in the medical record, if the soldier has the same injury to the same anatomical location 6 months later, consider it a new injury. If the soldier has the same injury to the same anatomical location <6 months later, consider it a follow-up visit for the earlier injury.

13. **Specific cases**

a. Pes planus - musculoskeletal pain, foot (PAIN; FOOT)
b. Iliotibial band syndrome - other tendonitis (OTH_TND)
c. Suture removal - follow up for previous laceration (ABRSN_LC)
d. Ingrown Toenail – Other traumatic injury (OTH_TI)
e. Sunburns, chemical burns – Other environmental/toxic injury (OTH_ENV)
f. Carpel tunnel syndrome – Other overuse (OTH_OU)
g. Cellulitis – If associated with blister, list as blister (BLISTER); if associated with abrasion/laceration, list as abrasion/laceration (ABRSN_LC))
e. Metatarsalagia – Pain, Foot (PAIN; FOOT)
f. RPPS (retropatellar pain syndrome), PFPS, PFS (Patellar-femoral pain syndrome) – RPPS
g. Ganglia – Other, musculoskeletal (OTH_MS)
h. Ligament tear – sprain, traumatic (SPRAIN)
i. Low back pain with neurological involvement (NEURO; LOWER BACK)
j. Rucksack palsy (NEURO; SHOULDER)
k. Heel spur (PAIN_OU; FOOT)

Some Abbreviations Used in Medical Records

General SOAP Profile

- S: Subjective (History)
- O: Objective (Symptoms)
- A: Assessment (Diagnosis)
- P: Plan (Treatment)

General Terms

- BCP - Birth Control Pills
- C/O - Complained Of
- CWP - Chest Wall Pain
- CXR - Chest X-ray
- C – With
- D/DX – Differential Diagnosis
- EEE - Erythema, Edema, Ecchymosis
- EPTS - may see existed prior to service
- F/U - Follow up
- FX - Fracture
- HCG - Human Chorionic Gonadotropin (Pregnancy Test)
- HPV - Human Pavo Virus (Warts)
- HX - History
- KUB - Kidney, Urethra, Bladder
- MEB - Medical Evaluation Board
- N/V - Nausea, Vomiting
- NAD - No Acute Distress
- NOS - Not Otherwise Specified
- NSU - Non-Specific Urethritis
- OCP - Ovulatory Control Pills (Birth Control)
- PRN - As Needed
- PMHx – Previous Medical History
- PSHx – Previous Surgical History
- R/O - Rule Out
- RX - Reaction/Prescription
- S/P - Suspect
- S - Without
- SOB - Short of Breath
- SocHx – Social History
- T-2, T-2, T-3 - Temporary Profiles
- TF2/TF3/TF12/Etc. - (Various Self Care Protocols)
- TL2 - Temporary Lower Body Profiles
- TTP - Tender to Palpation
- TTT - Tender to Touch
- TU - Temporary Upper Body Profile
- TX - Treatment
- URI - Upper Respiratory Infection

UTI - Urinary Tract Infection
WNL - Within Normal Limits
+O - Positive For
-O - Negative For
W/O - without
W – with